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European Union's renewable energy sources and energy efficiency policy review: The Spanish perspective

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Abstract

The European Union's (EU) energy objectives, legislation and programmes are determinant for the current strategy for the promotion of renewable energy sources (RES) and energy efficiency (EE) in Spain, which is becoming a key element for its international competitiveness.

Firstly, this article explores the evolution of the EU's energy strategy, focusing on the adopted legislations and programmes to promote RES and EE. It concludes with an analysis of the impact of those measures in Spain.

Keywords: Energy efficiency; Renewable energy sources; Carbon tax; Kyoto protocol; Energy policy; Solar energy model

Contents

Abbreviation: CCAA, Autonomous Communities; CTE, Technical Code for Buildings; EE, Energy Efficiency; EU, European Union; IDAE, Institute for the Energy Saving and Diversification; IPCC, Intergovernmental Panel on Climate Change; NAP, National Allocation Plan; RES, Renewable Energy Sources; RTD, Research and Technological Development.

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1. Introduction

The current centralised energy model, based on conventional sources of energy (mainly, coal, oil, natural gas and nuclear) [1–4], has been developed under the assumption that a direct relationship exists between prosperity (or wealth) and the increase in energy consumption. But this relation is now under challenge [5,6].

One of the biggest problems of this energy model is that, unless urgent measures are taken, the growing energy demand, linked to the reduction of the fossil fuel reserves and a longer energy chain,[1] will lead to an increase in the conventional energy fuel cost [2]. But, there are also other challenges directly linked with the mentioned model:

(i) Environmental damage caused by the conventional energy system [1,7–9], such as oil slicks, nuclear accidents, methane leaks, and of course, CO_2 emissions.[2]
(ii) Risks linked with the safety of the energy chain and the increase in the external dependence. If no action is taken, the European Union's (EU) dependence on external energy sources will increase from 50% to 70% by 2030 [1].

Despite these increasing costs and challenges, according to the last Action Plan on Energy Efficiency, Europe wastes at least 20% of its energy due to inefficiency. Consequently, realising the saving potential has been considered so far the most effective way to improve security of energy supply, reduce carbon emissions, foster competitiveness and stimulate the development of a large leading-edge market for energy-efficient technologies and products [10]. The European Commission affirms that the challenge of the European Energy Policy is to turn Europe into a highly energy efficient and low CO_2 energy economy, catalysing a *New Industrial Revolution*, accelerating the change to low carbon growth and, over a period of years, dramatically increasing the amount of local, low emission energy that we produce and use [11], and highlights that Renewable Energy Sources (RES) are the key to change [1].

The objective of the present article is to review the most important European legislation and programmes to promote RES and energy efficiency (EE),[3] focusing on their impact in Spain. The present study is limited to those measures focused on the improvement of the EE in the current *energy system*.[4]

In Section 2, a historical analysis of the EU energy strategy will be made. Section 3 is focused on the *solar energy model* and the EU goals on RES and EE. Section 4 reviews the most important legislation and programmes adopted by the EU for the promotion of the RES and EE. Finally, in Section 5, an analysis of the impact of the cited measures in the Spanish context will be presented.

2. The EU energy strategy

Apart from the adopted measures linked to transport sector,[5] the EU has made important efforts to develop the current energy model. We cannot forget that the EU grew out of the European Coal and Steel Community (ECSC) in 1951.[6] Later on, with the adoption of the Euratom Treaty in 1957, the founding Member States saw again the need for a common approach to energy [11]. These treaties, especially Euratom, have been very useful to co-ordinate European research and funding in this area [1].

It seems a paradox that the current European Union Treaty does not include any legal basis related to a Common Energy Policy,[7] so actions related to promote RES and EE have developed under different policies (external relations, internal market, environment, etc.), resulting in a lack of transparency both for political decision makers and industry [12–14].

Until the first energy crisis in 1973, the politics in the area of energy were basically related to guarantee the supply for the increasing energy demand. The principle was to link in a positive way energy consumption and prosperity [5]. After the 1973 oil crisis, the security of supply became critical, and different countries set off relevant measures to promote the RES and EE[8] in the framework of energy diversification [14]. However those initiatives seemed to have little relation with environmental concerns, and a lot with security of supply. In fact, worries about environmental problems were highlighted especially from the adoption of the First Environmental Action Programme for the period 1973–1976 [15,16].

[1]The energy chain includes the production, conversion, transmission and consumption of energy [2,4], which includes all the energy used from the extraction until the energy supplied to the consumer in the form of final service (e.g. light, heat, etc.).

[2]According to the IPCC, there is now clear scientific evidence that emissions from economic activity, particularly the burning of fossil fuels for energy, are causing changes to the Earth's climate [7–9].

[3]According to *2006/32/EC Directive*, EE is the increase in energy end-use efficiency as a result of technological, behaviour and/or economic changes. For the present analysis, the energy saving measures are also included in the EE concept.

[4]The *energy system* is related to the *energy chain* (see footnote 1).

[5]The Transport Policy is included in Titre V of the European Community Treaty as one of the EU's Common Policies.

[6]Which expired in 2002.

[7]Section 10 of the Treaty establishing a Constitution for Europe sets the following objectives for the EU's energy policy: (a) guarantee the energy market functioning/performance; (b) guarantee the energy security of supply; (c) to promote the energy saving and efficiency and the development of new and RES. However this Constitution has not been ratificated by all SM [12].

[8]In the Copenhagen Summit of December 1973, several resolutions were adopted related to EE, and the promotion of the RES. Later, in 1979 various regulations on financing RES were adopted [5].

The environmental aspects of energy and the necessity of promoting EE were already present in the European energy programmes adopted during the eighties as for example: VALOREN, PACE or JOULE [17–19]. But especially in the nineties, the concern about the couple energy consumption–environment became obvious, and this was evidenced by the adopted European programmes (see Section 5). From 1995, the following three key objectives for the European energy policy were established:

(i) Environmental protection;
(ii) Improvement of competitiveness;
(iii) Increase of security of supply [20].

Apart from the Energy Charter Treaty and the Energy Charter Protocol signed in 1994 [21], two other important agreements have been carried out by the EU outside its frontiers: the Kyoto Protocol (see Section 4.3), and the International Thermonuclear Experimental Reactor (ITER) project, which is the world's largest experimental facility to demonstrate the scientific and technical feasibility of fusion power, in which the EU financing is crucial[9] [22,23].

It cannot be forgotten that the evolution of the European energy policy is also directly related to the process of liberalisation and privatisation of the world energy markets, which started at the beginning of the eighties [1,14]. In 1986 the European Single Act, which included the objective of the creation of the Internal Market, was adopted. Gas and electricity were included as commodities under the Single Market Initiative and the Internal Energy Market became a key element of the European policy. Consequently, for more than 10 years, the so-called "liberalisation" of European national energy markets has been on the agenda. This "liberalisation" was followed by the adoption in 1996 of two important Directives: the *Directive 96/92/EC concerning common rules for the internal market in electricity*, and *Directive 98/30/CE concerning common rules for the internal market in natural gas* (these were later overruled by *Directive 2003/54/EC* and *Directive 2003/55/EC*, respectively). Despite the effort, according to the actual Director of the Directorate General for Competition of the EC, Philip Lowe, we do not yet have a single, competitive European energy market [24].

3. The solar energy model and the goals of the EU on RES and EE

The "ideal" *Solar Energy Model*, should be developed as a decentralised system,[10] taking into account the local necessities and resources, using a mix of local RES, where passive solar energy[11] and bioclimatique architecture have to become a key element [2,25]. In theory, this model, combined with the use of the hydrogen obtained from RES,[12] and energy storage technologies, could avoid one of the current problems of some RES, that is, the instability of supply [2]. The benefits linked with a massive production of energy through RES could be huge, they allow reductions in energy imports contributing to security of supply, temper effects of variations in oil and gas prices, reduce greenhouse gas emissions, increase local and specialized job creation etc. [2,5,6,11,14,25,26]. But also new environmental problems would arise, especially those related to the manufacturing of the RES units, and to the use of virgin lands to locate the RES units and/or to dedicate to the production of biofuels.[13]

In fact, the massive use of RES will not be a sustainable solution unless it is complemented with a real transformation of the economic development model, focusing efforts towards EE, adopting basic measures such as those proposed by the European Directives, but especially through more structural measures, as for example, adopting fiscal measures (e.g. carbon tax), changing current building patterns, reducing motorised mobility, etc. [2,10,14,28], that is, decoupling energy and resources consumption from wealth and economic growth.

Finally, it cannot be forgotten that unless current energy market barriers[14] and energy price distortion[15] are eliminated, RES will hardly become an alternative to conventional energy sources.

The EU adopted in 1997 the White Paper on RES, establishing the strategy to promote them, and setting a global indicative target a share of 12% of RES in the EU gross domestic energy consumption by 2010 [30]. Nevertheless, the share of renewable energy is unlikely to reach 10% by 2010. According to the European Commission, the

[9]The construction costs of the ITER are estimated in 5 billion euros over 10 years. Europe will contribute roughly to half of the costs of construction, while other parties will provide the rest of the budget.

[10]Here one of the main principles is that energy production has to be close to consumption, avoiding as much energy transport and distribution losses as possible and so reducing the energy chain (see footnote 1 [2]. See

(*footnote continued*)
also [4] to go deeper into the decentralised and distributed energy system concept.

[11]The *Passive solar energy* concept takes into account the use of the energy directly supplied by the sun (or even the wind) when the building design phase, considering also the building site and window orientation to reduce the use of additional mechanical equipment, other than the normal building elements, to obtain energy.

[12]According to Bermejo, the problem is that even if the hydrogen is promoted by the UE as a clean and "green" technology, 98% of it is produced from fossil fuels [25].

[13]It can be affirmed that this problem is already evident with biofuels [27].

[14]These market barriers can be natural (lack of information, lack of technical or technological development of some RES technologies, lack of escale economies, etc.), and also artificial (market power of traditional energy companies, administrative obstacles, etc.) [14].

[15]The current energy price distortion is not only due to the subvention legacy destined to the conventional energy model (according to the EC, only in nuclear research, the Community budget contributed EUR 2.9 billion [1]), but also because the important environmental "externalities" of the conventional energy sources [29] are usually not incorporated in the current energy market prices.

Table 1
Estimates for full energy-saving potential in end-use sectors

Sector	Energy consumption (Mtoe) 2005	Full energy saving potential 2020 (%)
Households (residential)	280	27
Commercial buildings (Tertiary)	157	30
Transport	332	26
Manufacturing Industry	297	35

Source: European Commission, EU-25 Baseline Scenario and Wuppertal Institute 2005. Obtained from [10].

main reasons for the possible failure to reach the agreed targets are: the lack of a coherent and effective policy framework throughout the EU with a stable long-term vision, and the increase in energy consumption [10]. However the Council of Ministers of 8th and 9th of May 2007 set a more ambitious target: a share of 20% of RES in the EU gross domestic energy consumption by 2020.

Regarding the promotion of the EE, the European Council endorsed in 1998 the following target for the Community: to improve energy intensity of final consumption by an additional 1% per year until 2010 [31]. More recently, the last Action Plan on Energy Efficiency has been adopted. According to this Action Plan, even though EE has improved considerably in recent years, Europe continues to waste at least 20% of its energy due to inefficiency, with an estimated direct cost of 100 billion euros annually by 2020. So, realising the savings, potential has been considered so far the most effective way to improve security of energy supply, reduce carbon emissions, foster competitiveness and stimulate the development of a large leading-edge market for energy-efficient technologies and products [10].

In Table 1 we can observe that, because of its large share of total consumption (around 40%), the largest cost-effective saving potential lies in the residential and commercial buildings sector, where the full energy saving potential is estimated to be around 27% and 30%, respectively [10]. Taking into account that in residential buildings, most of the energy consumed is used for heating [14,32], retrofitted wall and roof insulation offer the greatest opportunities to save energy, while improved appliances and other energy-using equipment still offer enormous energy saving opportunities. For the manufacturing industry, the overall potential is estimated to be around 25%, where peripheral equipment such as motors, fans and lighting[16] offer the most important saving potential. For transport, a similar full saving potential of 26% is estimated [10].

[16]A 20% of global electrical energy production today is used for lighting. The adoption of high efficiency Light Emitting Diode (LED) technology, already available on the market, could by 2015 save 30% of today's consumption for general lighting and 50% by 2025 [10].

4. Legislation to promote the RES and the EE

The present section is focused on the description of existing European Directives destined to promote RES and EE (Fig. 1). The analysis of these Directives will be developed in Sections 4.1 and 4.2. As explained before, the EE analysis is limited to those measures directly linked with the current energy system.

Section 4.3 is focused on *Directive 2003/87/EE* about greenhouse gas emission trading, due to its relevance for the energy system, and finally, Section 4.4 is focused on the proposal for a Directive to introduce a carbon tax in the EU.

4.1. Directives to promote the RES

In order to fulfil the objectives established in the White Paper on RES (see Section 3), and apart from the *Directive 2003/30/EC, on the promotion of the use of bio-fuels or other renewable fuels for transport*,[17] the EU adopted in 2001 the *Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market.* According to the Directive, the potential for the exploitation of RES is underused in the EU, so there is a need to promote them as a priority measure. Consequently, it establishes differentiated national indicative targets for each Member States for electricity produced from RES by 2010.[18] It also establishes an overall indicative target for the Community of 22.1%, but without setting any sectional targets for each RES.

In 2004 renewable electricity contributed 14% of overall EU electricity consumption while the starting point of the Directive was 13%. This is related to the higher than expected level of overall electricity consumption in Europe,[19] so the cited objectives only will be successful if they are followed by a strong energy consumption control policy. The situation varies considerably from one Member State to another, and in general, countries can be divided into three groups according to their amounts of progress regarding RES:

(i) Germany, Denmark, Spain, and Finland have implemented an energy policy which should enable them to reach their national targets.
(ii) Austria, Belgium, France, Ireland, the Netherlands, the United Kingdom, and Sweden have begun

[17]It is important to note that the transport sector accounts for more than 30% of final energy consumption in the Community, a trend which is bound to increase. This Directive establishes that Member States should ensure that a minimum proportion of bio-fuels and other renewable fuels is placed on their markets, establishing as a reference value of 5.75% of all petrol and diesel for transport purposes placed on their markets by 31 December 2010 (face to 0.6% in 2002).

[18]The indicative target for Spain is 29.4%.

[19]In the EU, the electricity consumption is growing at 2% per year, so according to the cited report, if the EU-25 electricity consumption had been constant since 1997, the current share of renewable electricity would now be 16%.

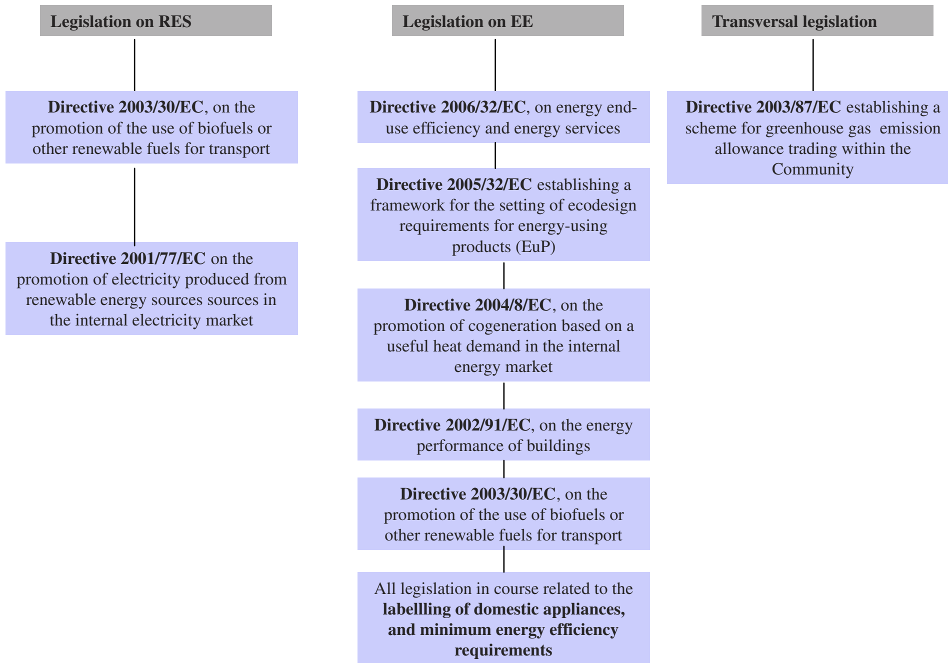


Fig. 1.

adopting policies and measures which would also allow them to achieve their national targets.

(iii) Greece and Portugal must improve their policies since these will not enable them to reach their targets [33,34].

It has to be noted that the European Commission adopted in 2005 a Bio-mass Action Plan, and is actually preparing a new Directive on RES heating and Cooling [35].

4.2. Directives to promote the EE

In order to fulfil the established targets in EE (see Section 3), the following legislation is in course:

(a) *Directive 2006/32/EC, on energy end-use efficiency and energy services*:[20] The aim of this Directive is not only to promote the supply side of energy services, but also to create stronger incentives for the demand side. Its purpose is to enhance the cost-effective improvement of energy end-use efficiency in the Member States by means of:
  (i) provision of the necessary indicative targets as well as mechanisms, incentives and institutional, financial, and legal frameworks to remove existing market barriers and imperfections that impede the efficient end use of energy;
  (ii) creation of the conditions for the development and promotion of a market for energy services and for the delivery of other EE improvement measures to final consumers.

[20]Repealing Council Directive *93/76/EEC*.

According to the Directive, Member States shall ensure that there are sufficient incentives, equal competition, and level playing fields for market actors (other than energy distributors, distribution system operators, and retail energy sales companies), such as ESCOs,[21] installers, energy advisors, and energy consultants, to independently offer and implement the energy services, energy audits, and EE improvement measures. The problem is that, even if the Directive establishes an indicative energy saving target, it entails no legally enforceable obligation for Member States to achieve it.

(b) *Directive 2004/8/EC on the promotion of co-generation*[22] *based on a useful heat demand in the internal*

[21]ESCO is a natural or legal person that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accepts some degree of financial risk in doing so. The payment for the services delivered is based (either fully or in part) on the achievement of energy efficiency improvements and on the meeting of the other agreed performance criteria. Here we can include: (i) "energy performance contracting": a contractual arrangement between the beneficiary and the provider (normally an ESCO) of an energy efficiency improvement measure, where investments in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement. And (ii) "third party financing", that is, a contractual arrangement involving a third party (in addition to the energy supplier and the beneficiary of the energy efficiency improvement measure) that provides the capital for that measure and charges the beneficiary with a fee equivalent to a part of the energy savings achieved as a result of the energy efficiency improvement measure. That third party may or may not be an ESCO [14,36,37].

[22]Cogeneration (also Combined Heat and Power, CHP is the simultaneous generation in one process of useful thermal energy and electrical and/or mechanical energy. The Directive defines high efficiency

energy market[23] [38]: In its 1997 Communication on the promotion of co-generation, the European Commission called for doubling of co-generation production from 9% to 18% of European electricity generation by 2010, as a non-binding target [39,40].

In terms of installed capacity, the share of electricity produced by co-generation processes has raised to 10% in the EU in 2001. However, large differences exist among the Member States, with variations of the share between 2% and 60% of the electricity production [40]. Hence, the new Directive concentrates on providing a framework for the promotion of this efficient technique in order to overcome still existing barriers, to advance its penetration in the liberalised energy markets and to help mobilising unused potentials.

The main contributions by the Directive are: (i) the establishment of a harmonised method for calculation of electricity from co-generation and necessary guidelines for its implementation; (ii) the requirement for Member States to ensure that the origin of electricity produced from high-efficiency co-generation can be guaranteed. Its main drawback is the failure to establish any quantitative target of the minimum electricity generation by co-generation required.

Next, the existing legislation related to EE requirements of different products and buildings, which represents the basis of the regulatory tools in the energy area [41], will be described:

(a) *Directive 2005/32/EC establishing a framework for the setting of eco-design*[24] *requirements for energy-using products (EuP)*[25] [42]: This framework Directive requires that before a EuP is placed on the market, a "CE conformity" marking will be affixed. The objective is that information concerning the product's environmental performance and EE must be visible if possible on the product itself, thus allowing consumers to compare before purchasing. Other objectives are to ensure the free movement of those products within the internal market, to open the way for more effective schemes,[26] and to complement the existing Community eco-label system.[27] This framework Directive amends and integrates the following Directives: *92/42/EEC*,[28] *96/57/EC*,[29] and *2000/55/EC*,[30] related to the minimum efficiency requirements for hot water boilers, electric refrigerators, and ballast and fluorescent lighting, respectively.

(b) Closely related to this *2005/32/EC framework Directive*, and apart from the existing voluntary agreements with industry agents, that sometimes have become an alternative to legislation [43], a wide range of legislation related to energy certification exists for the labelling of domestic appliances. These Directives have been established in an effort to increase the flow of accurate and objective consumer information. In this sense we can mention, for example:
- *2003/66/EC Directive*[31]: with regard to energy labelling of household electric refrigerators, freezers, and their combinations, which made it possible for consumers to identify easily those refrigerators and freezers which consume the least energy by referring to the indications "A+" (efficient) and "A++" (most efficient) on the sale labels of such products.
- *2002/40/EC Directive*[32]: with regard to energy labelling of household electric ovens.
- Etc.[33].

(c) *Directive 2002/91/EC on the energy performance of buildings*: The motivation for the adoption of this Directive is that the residential and tertiary sector (most part of which are buildings) accounts for more than 40% of final energy consumption in the Community and is expanding [44], so a bad conception or inadequate construction methods can increase the long-term energy consumption, which leads to increasing maintenance prices due to the necessity of extra heat or refrigeration [32].

The main objective of the Directive is to create a common framework to promote the improvement of the energy performance of buildings, following the line started by some previous Directives (especially the *SAVE Directive 96/76/CEE* destined to limit carbon

(*footnote continued*)
co-generation as co-generation providing at least 10% energy savings compared to separate production [38].

[23]Amending Directive *92/42/EEC*.

[24]Ecodesign: the integration of environmental aspects into product design with the aim of improving the environmental performance of the energy-using product throughout its life cycle.

[25]The Directive will be applied to the following product groups as a matter of priority: heating and water heating equipment, electric motors, lighting in the residential and tertiary sectors, domestic appliances, office equipment in the residential and tertiary sectors, consumer electronics, HVAC (heating, ventilation, and air conditioning) systems.

[26]Taking into account that the star rating system and the Directive *92/42/EEC* have proved not to deliver the expected result [9,44].

[27]The present Directive is complementary to the Regulation (EC) number *1980/2000* on a revised Community eco-label award scheme. Products that have been granted with the eco-label are presumed to be in compliance with the ecodesign requirements, so far as these requirements are covered by the eco-label.

[28]Amended by Directive *93/687EEC*; *2004/8/EC*, and *2005/32/EC*.

[29]Amended by *2005/32/EC*.

[30]Amended by *2005/32/EC*.

[31]Amending Directive *94/2/EC*.

[32]Implementing Council Directive *92/75/EEC* on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances.

[33]Other similar Directives: Directive *2002/31/EC*; Directive *1999/9/EC* (amending Directive *97/17/EC*); Directive *98/11/EC*; Directive *96/60/EC*; Directive *95/13/EC*; Directive *96/89/EC* (amending Directive *95/12/EC*); and Directive *79/531/EEC* (cancelled by Directive *92/75/EEC*). All these Directives are implementing measures of *92/75/EEC* Directive.

dioxide emissions by improving EE[34]), and requires Member States to:

- Apply a methodology of calculation of the energy performance of buildings;
- Establish minimum requirements on the energy performance of new buildings and large existing buildings that are subject to major renovation;
- Emit an energy performance certificate when buildings are constructed, sold, or rented out;
- Carry out regular inspection of boilers and of air-conditioning systems in buildings.

It can be highlighted that the mentioned *SAVE Directive 93/76/CEE* has had very different impact among Member States. In Denmark, the system related to the energy certification of buildings already existed before this SAVE Directive. Instead, as shown in Section 6, countries like Spain or Portugal, are actually developing a process to implement these kind of systems according to *Directive 2002/91/EC* [41,45]. On the other hand, the non-existence of quantitative targets and the non-definition of the methodology of calculation of the energy performance of buildings could lead to the adoption of ineffective methodologies among Member States (see Section 6). It is important to highlight that the cited energy performance requirements and certificates only affect new buildings or large existing buildings that are subject to major renovation, consequently they do not affect a great part of the existing buildings.

4.3. Kyoto Protocol: Directive 2003/87/EC establishing a scheme for greenhouse gas [35] emission allowance[36] trading within the Community[37]

According to the Kyoto Protocol, the EU committed itself to reducing its greenhouse gas emissions by 8% during the period 2008–2012 in comparison to its levels in 1990, while each Member State has its own reduction target. For example, Spain can raise its CO_2 emissions to 15% in 2012 in comparison with its level in 1990 [46]. Wishing to fulfil the cited commitments, in 2003 the *Directive 2003/87/CE establishing a scheme for greenhouse gas emission allowance trading within the Community* was adopted. The emission trading is a scheme whereby entities such as companies are allocated allowances for their emissions. Companies that reduce their emissions by more than their allocated allowance can sell their "surplus" to others who are not able to reach their target so easily. It must be said that the EU emission allowance trading is the first multinational system existing in the world, and is considered a precursor of the international system according to Kyoto. This trading scheme does not undermine the environmental objective, since the overall amount of allowances is fixed [47]. But problems have arisen because:

(i) The Directive does not fix the quantity of total allowances to be allocated by Member States, so they became responsible of determining the total quantity of allowances to allocate to the affected sectors by a National Allocation Plan (NAP).[38] In any case, the European Commission is in charge of the revision of the cited NAPs, and it may reject those plans, or any aspect of them. It has to be noted that, the Directive distinguishes two periods, and it is foreseen to increase the exigencies from the second period, that is, from the year 2008.[39]
(ii) The "diffuse sources", that is the transportation and household, with a huge energy save potential (see Section 3), are not actually included in the framework of this Directive.

4.4. Fiscal measures: proposal for a Council Directive Introducing a Tax on Carbon Dioxide Emissions and Energy

Several authors call for the use of tax to face environmental problems [48–50]. According to M. Friedman, a better way to control pollution is to introduce discipline by taxing wastes, instead of traditional methods of supervision and specific regulation [50]. Other authors go even further asking for a deep Ecological Tax Reform, which could tax elements, such as the emission of polluting agents, instead of positive elements as the human work [28,51].

Some countries like Denmark, Holland, etc. have already included a Carbon Tax in their tax system [52,53], which can be considered a first step in the direction of internalising the environmental "externalities" in the current energy prices [54], and could lead to eliminate part of existing price distortions favouring the penetration of RES (see Section 3).

It has been estimated that a global carbon tax would have double the impact of a national tax [52]. However, because of the need of unanimity in the tax area [14], all the work made to include a tax on carbon dioxide emissions in the EU have been unsuccessful, and finally the *proposal for a Council Directive Introducing a Tax on Carbon Dioxide Emissions and Energy of 1992*, was withdrawn [55]. However, the last Action Plan on Energy Efficiency has the objective to review the European Tax system to

[34] This SAVE Directive was repealed by Directive *2006/32/EC*. Another Directive also related with buildings is Directive *89/106/EEC* on the approximation of laws, regulations, and administrative provisions of the Member States relating to construction products.

[35] This greenhouse gas is listed in Anex II of the Directive, in any case, initially the Directive only affects to CO_2 emissions.

[36] "Allowance" means an allowance to emit one ton of carbon dioxide equivalent during a specified period.

[37] Amending Council Directive *96/61/EC*.

[38] For the Spanish case, see Section 6.

[39] According to the Directive, for each period Member States will develop a NAP determining the total quantity of allowances to allocate and how it proposes to allocate them between the affected sectors. In the first period (three-year period beginning 1 January 2005) Member States will allocate at least 95% of the allowances free of charge. In the second period (five-year period beginning 1 January 2008), Member States will allocate at least 90% of the allowances free of charge.

Table 2
VI RTD FP: maximum overall financial amount[a]. (Eur million)

1. Focusing and integrating Community research			13.345
1.1. Thematic priorities		11.285	
1.1.1. Life sciences, genomics and biotechnology for health	2.255		
1.1.2. Nanotechnologies and nanosciences, knowledge-based multifunctional materials and new production processes and devices	1.300		
1.1.3. Sustainable development, global change, and ecosystems	2.120		
1.1.4. Citizens and governance in a knowledge-based society	225		
1.2. Specific activities covering a wider field of research	1.300		
2. Structuring the European Research Area			2.605
3. Strengthening the foundations of the European Research Area			320
Total			16.270

Source: [56].
[a]Excluding nuclear activities.

promote the EE [30], so maybe there is still a chance for an EU Carbon Tax in the future.

Finally, it should be noted that some Directives linked with energy taxation are in force nowadays,[40] but they are more related to the consecution of an Internal Energy Market, than to the reduction of fossil fuels consumption.

5. European programmes for the promotion of the RES and EE

This section describes the existing European programmes directly related with the energy area, and will especially be focused on those oriented to the promotion of the RES and the EE.

5.1. Research and Technological Development Framework Programmes

The Research and Technological Development (RTD) Framework Programmes are multi-annual programmes where the EU scientific objectives and research priorities are established for the following years. These programmes also include the specific action lines to be developed and their financial allocation. All actions financed by RTD Framework Programmes have to be focused on the development of new technologies, in pre-competitiveness phase.

The interest of the EU in promoting the RES and energy clean technologies was already highlighted in previous RTD Framework Programmes, as for example, through the JOULE programme,[41] or the "Energy, Environment and Sustainable Development" programme, which was implemented under the V Framework Programme for the period 1999–2002. Later, the VI Framework Programme for the period 2002–2006 was adopted, with a total budget of 16.270 million euros (research in nuclear power has its own separate budget. See Tables 4 and 5). "Sustainable development, global change and ecosystems" were included as a thematic priority in the cited Framework programme, with an approximated budget of 2.120 million euros (See Table 2), and included the following programmes:

(i) "Sustainable energy system" (budget 810 million euros);
(ii) "Sustainable surface transport", (budget 610 million euros);
(iii) "Global change and ecosystem Member States" (budget 700 million euros) [56].

Recently the VII RTD Framework Programme has been adopted for the period 2007–2013 [57]. Apart from the Euratom Specific Program for nuclear power (see Table 4), the maximum overall amount for this Programme will be 50.521 million euros. That budget will be distributed among the different programmes and activities as described in Table 3. The "Energy" area is included as a thematic area into the "Co-operation Programme", with an indicative budget of 2.350 million euros. The objective of the "Energy" area is to adapt the current energy system into a more sustainable one.[42]According to the cited objective, the research fields that will be promoted are:

(i) Hydrogen and fuel cells;
(ii) Renewable electricity generation;
(iii) Renewable fuel production;
(iv) Renewable for heating and cooling;
(v) CO_2 capture and storage technologies for zero emission power generation[43];

[40]These Directives are: Directive *92/12/CEE*; Directive *92/81/CEE*; and Directive *2003/96/CE*.

[41]This has financed relevant research projects such as the *Interdisciplinary Analysis of Successful Implementation of Energy Efficiency in the industrial*, *commercial*, *and service sector* [52] or the *Externe-E project* about the environmental externalities of different energy sources [29].

[42]Defining it as less dependent on imported fuels and based on a diverse mix of energy sources, in particular renewables, energy carriers and non-polluting sources; enhancing energy efficiency, rationalising the use and storage of energy; addressing the pressing challenges of security of supply and climate change, while increasing the competitiveness of Europe's industries.

[43]Including research, development and demonstration of technologies to reduce drastically the environmental impact of fossil fuel use, aiming a highly efficient and cost effective power, and/or heat generation plants,

Table 3
VII RTD FP: Maximum overall financial amount[a] (Eur million)

Cooperation	32.413
Ideas	7.510
People	4.750
Capacities	4.097
Non-nuclear actions of the Joint Research Centre	1.751
Total	50.521

Source: [57].
[a]Excluding nuclear activities.

Table 4
Maximum overall financial amount for nuclear activities (Eur million)

VI RTD Framework Programme	VII RTD Framework Programme
1.230	2.751

Source: [58–60].

(vi) Clean coal technologies[44];
(vii) Smart energy networks[45];
(viii) EE and savings;
(ix) Knowledge for energy policy making.

It has to be noted that, this "Co-operation Programme" also includes the "Environment (including Climate Change)"[46] and "Transport"[47] thematic areas, which could also be used for financing topics related to the RES and EE.

Nuclear activities have their own finance in the different RTD Framework Programmes as shown in Table 4. Table 5 shows the assignment of 2.751 million euros for research on the nuclear power in the VII RTD Framework Programme, where the great importance of the ITER fusion project can be highlighted.

Table 5
Financial distribution destinated to different nuclear activities

Fusion energy research[a]	1.947
Nuclear fission and radiation protection	287
Nuclear activities of the Joint Research Centre	517

Source: [60].
[a]Within the amount foreseen for fusion energy research, at least EUR 900 million will be reserved for activities other than the construction of ITER, listed in Annex II of the present Council Decision.

5.2. Non-technological programmes for the promotion of RES and EE

The first SAVE programme was adopted in 1991. This programme is considered the main non-technological action on EE of the EU. The objective is to encourage energy-saving behaviour in industry, commerce, and the domestic sector, as well as in transport, through policy measures, information, studies and pilot actions, international conferences, energy-labelling programmes, etc. Many of the local energy management and information agencies all around Europe have been created using the SAVE programme. As a result, most of existing Spanish Local Energy Agencies were created. These kind of agencies have played a relevant role in the development of EE and RES related legislation in Spain, and could became key actors to improve education and information about RES and EE in this country [14].

In 1993 the Altener programme, concerning the promotion of RES, was adopted [61,62]. Altener has promoted very important projects such as TERES,[48] BIOHEAT,[49] etc. Altener also included the setting up of high dissemination projects, such as the Managenergy web,[50] which includes all kind of relevant information regarding local energy Demand Side Management, and becomes a relevant tool for local energy actors, including the Local Energy Agencies [14].

In 1998, the first Framework Programme for actions in the energy sector was adopted for the period 1998–2002. The thematic priorities of the programme included not only the promotion of RES and EE, but also the international co-operation in energy, and activities in the area of conventional energy, especially in the nuclear area. The aim of this multi-annual programme was to integrate

(*footnote continued*)
with near zero emissions, based on CO_2 capture and storage technologies, in particular underground storage.

[44]Including research on clean coal and other solid fuel conversion technologies, including chemical processes, also producing secondary energy carriers (including hydrogen), and liquid gaseous fuels. Activities will be linked as appropriate to CO_2 capture and storage technologies or co-utilisation of biomass.

[45]Including research, development and demonstration on how to increase the efficiency, safety, reliability, and quality of the European electricity and gas system and networks; e.g. by transforming the current electricity grids into an interactive (customer/operator) service network, developing energy storage options and removing obstacles to the large-scale deployment and effective integration of distributed and RES.

[46]With a budget 1.890 million euro.

[47]With a budget 4.160 million euro.

[48]TERES is a Europe-wide study of renewable energy potential TERES "The European Renewable Energy Study" (*1991-ITC/DG17/EEC*), and was followed by TERES II.

[49]BIOHEAT offers a lot of valuable information about the promotion of biomass heating in large buildings and blocks; BIOHEAT "Promoting biomass heating in large buildings and blocks": http://www.bioheat.info/

[50]Managenergy is an initiative of the Directorate-General for Energy and Transport (DGTREN), which aims to support the work of actors working on energy efficiency and renewable energies at the local and regional level. The main tools are training workshops and online events, information on case studies, good practices, and European legislation and programmes. (see: www.managenergy.net).

and co-ordinate the existing actions and programmes in the energy field [63].

In 2002, the programme "Intelligent Energy for Europe" was adopted for the period 2003–2006, with an approximated budget of 215 million euro. This programme continued the existing SAVE and Altener, and included two new programmes: Synergy, related to energy aspects of transport, and Coopener, related to the promotion of RES and EE in the developing countries [64]. Table 6 shows the evolution of funding of energy related programmes between 1998–2006.

Actually the Competitiveness and Innovation Framework Programme is in force for the period 2007–2013, with an estimated overall budget of 3.621 million euro. This Framework Programme will be implemented by the following specific programmes:

(i) Entrepreneurship and Innovation Programme, with 60% of the overall budget;
(ii) Information and Communications Technologies (ICT) Policy Support Programme, with 20% of the overall budget;
(iii) Intelligent Energy-Europe Programme, with 20% of the overall budget [66].

Consequently, the estimated total budget for Intelligent Energy-Europe programme is approximately 724.26 million euro. SAVE, ALTENER, STEER, which are a continuation of the existing programmes, and the action called "integrated activities" will share this budget [66].

As it has been described in previous sections, one of the most important action lines of the European energy policy is the promotion of the EE through energy labelling and minimum EE requirements. In this sense, we can include the Energy-Star, promoted by SAVE, and also the Green-Light voluntary programmes [67,68].

Other existing funds could also be used to promote RES and EE in the EU framework. For example, according to the European Commission, investments under Structural Funds in less developed European regions should concentrate on the development of energy networks, EE, and the RES, while for the whole of Member States, investment would tend to focus on small-scale innovative infrastructure projects [69]. In the area of Common Agricultural Policy and the rural development policy, Agenda 2000 invites Member States to encourage RES [70,71]. Some transport-related initiatives cannot only be a real improvement for the promotion of RES, especially bio-fuels, but also for EE, for example improving local public transport. In this sense we can highlight:

(i) CIVITAS III initiative, which helps cities to achieve a more sustainable, clean and energy efficient urban transport system by implementing and evaluating an ambitious, integrated set of technology, and policy-based measures [72].
(ii) SMILE project, developed by the DG Environment of the European Commission within the LIFE programme, which establishes that sustainable mobility should reconcile citizen's mobility needs with quality of life and environment [73].

Table 6
Financial contribution to the promotion of RES and EE (1998–2006)

Eur million (indicative)	1998–2002	2003	2004	2005	2006	Total
SAVE	66	21	18	18	18	141
ALTENER	77	23	21	21	21	163
ETAP	5					5
SYNERGY	15					15
CARNOT	3					3
STEER		4	11	9	11	35
COOPENER		2	5	7	5	19
TOTAL	166	50	55	55	55	381

Source: [61–65].

6. The Spanish case

The most relevant capabilities to develop national energy systems are nowadays in the hands of Member States. According to the Spanish Constitution, a highly decentralised administrative system is in force. Apart from the National Government, Autonomous Communities (CCAA) and to a lesser extent, Local Entities, have important contributions in the energy sector. On the other hand, CCAAs and especially the Local Entities are mainly responsible for urban planning, and the provision of the public local transportation, areas with a big energy saving potential in this country [14].

In the EE area, the current National Strategy is compiled in "E4" [74], including its Action Plan 2005–2007 (with an overall budget of 729.122 million euro [75]). In the RES area, the RES Promotion Plan 2005–2010 [76] is the key document, and according to the European targets, it establishes that the 12.1% of the primary energy consumption for the year 2010 will be supplied with renewable energies. Without doubt, the European Energy objectives and legislation have been determinant for the main guidelines of both strategies.

The Institute for the Energy Saving and Diversification (IDAE),[51] is the Spanish institution in charge of the execution of the RES and the EE Promotion Plans, which have to be developed through collaboration agreements signed between the Spanish Government and the CCAAs [75].

Regarding the implementation of the EE and RES related European Directives in Spain, we can distinguish:

(a) *The EE area*: The recent evolution of the Spanish energy intensity ratio compared with other State

[51] A semi-public commercial entity dependent on the Treasury through the State Secretary for Energy, Industrial Development and Small and Medium-sized Business in accordance with Royal Decree 777/2002.

Table 7
Washing machine sales according to the energy efficiency indication (%)

Energy class	2001	2003
A	16	29
B	22.9	24.9
C	26.5	19
D	4.4	1.4
E	0.2	0
F	0.1	0
G	0.1	1
Not identified	29.7	24.5

Source: [81].

Table 8
Refrigerator sales according to the energy efficiency indication (%)

Energy class	2001	2003
A	2.8	8.6
B	30.1	38.3
C	34.8	25.4
Combined	0.2	0.1
D	1.3	0.5
E	0.7	0.1
F	0	0
G	0.3	0.1
Not identified	29.9	26.9

Source: [81].

Table 9
Freezer sales according to the energy efficiency indication (%)

Energy class	2001	2003
A	0.3	1.1
B	4.2	4.3
C	13.8	18.4
D	13.2	14.7
E	22.8	21.1
F	6.9	2.2
G	9.2	7.4
Not identified	29.7	30.9

Source: [81].

Members[52] [77] is very worrying for its international competitiveness [14,78,79]. This evolution has been mainly due to: a certain delay in the development and wealth of this country; the lower energy prices [80]; and a lack of sensitivity on energy saving and efficiency in the past [14,80]. The improvement of equipment of residential households and tertiary buildings, and the development of road infrastructures explain a great part of the increase in the energy intensity ratio [14,74].

It is remarkable that only 33% of the Spanish population knew the existence of the European energy labelling system [74]. Moreover, as it is shown in the tables, the market penetration of efficient electric household appliances in Spain is very low (Tables 7–9).

One of the most relevant legislation envisaged to fulfil the objectives of the *Directive 2002/91/EC* about energy performance of buildings is the adoption in 2006 of the Royal Decree related to Technical Code of Building (CTE) [82], suited by the Regulation for Thermal Installation of Buildings (RITE),[53] and the Energetic Certification of Buildings.[54] The CTE represents the new legislative basis that new buildings have to follow in terms of security and habitability, and will be a key element to understand the future EE of new buildings in Spain. Even if it seems too soon to extract any conclusion,[55] there are doubts about the effectiveness of this Royal Decree, because it does not

Table 10
Installed per capita photovoltaic energy (Wp/hab) in EU

Country	Wp/hab
Luxemburg	58.16
Germany	9.61
Holland	2.93
Austria	2.43
Spain	0.91
Finland	0.71
Italy	0.52
Sweden	0.46
Greece	0.43
Denmark	0.42
France	0.34
Cyprus	0.25
Portugal	0.23
Belgium	0.14
United Kingdom	0.13
Slovenia	0.04
Check Republic	0.04
Ireland	0.03
Malta	0.02
Hungary	0.01
Eslovaquia	0.01
Poland	0.01
Lithuania	0.00
Latvia	0.00
Estonia	0.00
UE	2.20

Source: [91].

[52] The Energy intensity ratio usually refers to the amount of primary or final energy consumed per unit of GDP (Toe/M.euro). Until recently, this ratio has increased considerably in Spain, while in the rest of State Members (the 15) with the exception of Portugal) it has decreased [77].

[53] Real Decreto 1218/2002, de 22 de noviembre, por el que se modifica el RD 1751/1998, de 31 de julio, por el que se aprobó el RITE.

[54] Real decreto 47/2007, del 19 de enero de 2007 por el que se aprueba el Procedimiento básico para la certificación de eficiencia energética de edificios de nueva construcción.

[55] Its application began in January 2007.

Table 11
Installed per capita thermic energy in some SM (m2)

Country	m2 installed in 1999	m2 installed in the last of 1999	m2 installed for each 1000 inhabitants in 1999	Increase (%)
Germany	420.000	2290.000	5.1	20
Greece	160.000	2645.000	15.2	3
Austria	141.000	1476.000	17.5	−15
Italy	24.000	244.000	0.4	20
Portugal	4.500	219.000	0.5	−10
Spain	33.000	313.000	0.8	50
Total Europe	890.000	8482.000	2.4	7

Source: [92].

include quantitative information on energy consumption in buildings, measured as Kw h/m^2-year [43].

(b) *RES area*: There is a huge disparity regarding RES and EE promotion policies among Spanish CCAAs [14]. While some CCAAs are considered leaders in the promotion of RES in a European framework especially from the half of the nineties, as is the case of Navarra [14,83,84], others have shown little interest in this field [14,84].

Spain is a world leader in wind turbine manufacturing and wind power penetration [14,85]. According to Martinez, despite the Royal Decree 1818/1998 represented the key to the increase in installed wind energy in Spain, hurriedness was introduced with the adoption of Royal Decree 436/2004 [86]. The previous 25th of May, the new Royal Decree 661/2007 was adopted [87], which will represent the key for the future penetration of the wind technology in the Spanish market. This law introduces limits to the rentability of new wind energy projects, which could be a reason for the slowing of development of new wind projects.

Spain is considered a leader regarding the manufacture of photovoltaic technology [88,89], and recently the first commercial scale concentrating solar power plant in Europe has been inaugurated in this country[56] [90]; paradoxically, until the first years of the XXIth century, the installed *per capita* photovoltaic and thermic solar energy has been much lower than the European average (see Tables 10 and 11). According to IDAE, the Royal Decree 436/2004,[57] has been the reason for the recent improvement of the photovoltaic market penetration in Spain [85]. But without doubt, the recent changes established by the new Royal Decree 661/2007 will be the key for the future solar market penetration in this country. According to the *Asociación de Productores de Energías renovables* (APPA), this new Royal Decree provides the necessary stability and predictability to be able to fulfill the established European and Spanish targets on RES [93], especially in light of the transition period for the RES already included in the previous Royal Decree 436/2004.[58]

Regarding solar thermal power, the CTE has just introduced the obligation to install a minimum thermal solar power in new buildings in Spain[59] [82]. So an adequate enforcement of this Law is of primary importance for the implantation of this technology [14].

The alarming increase in the Spanish energy consumption is the biggest obstacle to comply with the objectives established by the different RES Promotion Plans,[60] especially in the area of biomass, solar, and mini-hydraulic [85], so a bigger effort in EE is fundamental in this country.

(c) *Additional Directives*: Nowadays Spain is renewing efforts against Climate Change [94], and recently the Spanish Climate Change Bureau, which compiles and reviews the studies related to climate change impacts assessment, has been created [95], but still a National Strategy on Climate Change has not been adopted [96].

The Spanish CO_2 emissions in 2004 were 47.9% over 1990 levels [97], which is very far from the 15% agreed among EU members after the Kyoto Protocol agreement (see Section 4.3). The current Spanish NAP 2008-2012 is in charge of distributing CO_2 emission allowances among owners of those installations affected by *Directive 2003/87/CE,* which represents approximately 40% of the total emissions in Spain. The NAP 2008–2012 establishes as quantitative target for the year 2010, an increase in total emissions (including also the *diffuse sources*) of 37% of the emissions of 1990,[61] decreasing the objective of emissions reductions of the previous NAP 2005-2007, which was

[56]The 11 MW plant (partly financed by the V RDT Framework Programme), was inaugurated on the 30th March 2007, and has been designed to produce 23 GWh of electricity a year.

[57]This Royal Decree linked the evolution of the price of RES to the TMR (reference tariff fixed on the basis of the average initial costs), but this has been eliminated with the adoption of Royal Decree 661/2007.

[58]According to RD 661/2007 this RES could maintain the conditions established by RD 436/2004 until 31-12-2012.

[59]Unless other alternative solutions are adopted (Art 5 of the CTE).

[60]According to IDAE, in 2004 the RES only supposes 6.5% of the primary energy consumption in Spain, a percentage even lower than in 1999, when the RES Promotion Plan 1999–2010 was approved.

[61]The difference between the limit imposed by the EU of the 15% and the 37% established in Spain will be compensated by emission allowances (20%) (7%) and removals by CO_2 sinks (max 2%).

27%[62] [97,98]. Taking into account that the emissions allocated by the current NAP 2008–2012 have decreased sensibly comparing with those allocated by NAP 2005–2007,[63] we can conclude that:

(i) the biggest expected increase of emissions are related to the *diffuse sources*, that is, the transportation and households, which are not affected by *Directive 2003/87/CE*.
(ii) Spain will have to buy more CO_2 emission allowances than expected in previous NAP 2005-2007 to fulfill its Kyoto Targets.

Besides being more restrictive in the emission reduction targets, more effort is required to reach the objective of 37%, especially for the *diffuse sources*. Nowadays, the E4 and its Action Plan 2005–2007 are the main documents to explain the Spanish EE strategy, until the Spanish National Strategy against Climate Change is adopted. But taking into account the continuous increase of the Spanish energy consumption, it seems that they are not enough to achieve the targets.

7. Conclusions

Over the last decades, the energy-related European programmes have increased notably the budget targeted for the promotion of RES and EE. These programmes have been fundamental for the improvement of the research, the diffusion of information, and the development of relevant pilot projects all around Europe, specially in the RES area. However, the majority of the funds that the current VII RTD Framework Programme (2007–2013) targeted to the energy area are focused on nuclear energy (2.751 million euro), and especially on fusion power, while non-nuclear technologies, including RES, are expected to receive 2.350 million euros.

European Directives related to RES have supposed a major boost for the development of these technologies in Europe and in Spain, but the alarming increase in the energy consumption is the main obstacle to comply with the established objectives. Spain is considered a world leader in the production of wind and solar technologies and in market penetration of wind energy. Paradoxically, despite its high solar potential, Spain has been far from the European average in installed *per capita* solar thermal and photovoltaic energy, so a more balanced development of RES should be suitable. Future development of RES technologies depends mainly on the juridical stability, which seems to be guaranteed for the majority of the affected technologies with the recently approved Royal Decree 661/2007; however, this new Royal Decree could also be a reason for the slowing of development of new wind projects. On the other hand, the adequate enforcement of the CTE will become of primary importance for the implantation of the solar thermal power in buildings in the near future.

Most of the analysed Directives on EE are oriented to establish minimum EE requirements or Design Standards and labelling systems to promote a more efficient consumption, especially in the residential and building sector, so they do not mean a real change in the current energy consumption patterns. However, as the current Spanish EE strategy (E4) shows, only using basic EE measures, as those proposed by the European Directives, a considerable saving potential is still possible in this country. The recently adopted CTE is the main law destined to fulfil the objectives of the *Directive 2002/91/EC* to improve the energy performance of buildings, but its effectivity to reduce the real energy consumed by the affected buildings is still to be proved. The problem is that the evaluation of results is difficult using the established methodology.

Even if the inclusion of some environmental "externalities" through a European Carbon Tax has not been possible until now, relevant advance has been made regarding the Kyoto commitments with the adoption of the *Directive 2003/87/EC*, which establishes CO_2 emission trading in the EU. However, the effectiveness of this Directive to reduce CO_2 emissions depends mainly on the total emissions allocated by different NAPs. Even if the current Spanish NAP 2008-2012 has reduced the emission allowances among the affected sectors compared to previous NAP 2005-2007, Spain will have to buy more CO_2 emission allowances than expected in the NAP 2005-2007 to accomplish its objectives, unless urgent measures are adopted.

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[62] The objective of NAP 2008–2012 is an increase in total emissions of 37% while the objective of previous NAP 2005–2007 was an increase in total emissions of 24% of the emissions of 1990. The difference between the limit imposed by the EU of 15% and the new Spanish objective (37%), should be compensated by emission allowances (20%) and removals by CO_2 sinks (max 2%), while according to the previous NAP 2005-2007 Spain only had to compensate 7% by emission allowances to fulfil the objective of 27%.

[63] The stabilised decrease in the emission allowances is between 11% and 16%.

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